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EVALUATION THREE SCINTILLATORS USED FOR ACTIVITY MEASUREMENT OF BIOSOLAR USING LIQUID SCINTILLATION COUNTER

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ABSTRACT

Three scintillators, ultimagold, aqualight, and aquasol, have been applied to compare performance of liquid scintillation counter upon its C-14 activity measurement in biodiesel supplied by Pertamina in Makassar. The results showed that efficiency of aquasol is lower (0.2), while aqualight and ultimagold is higher (> 0.5). However eff iciency stability of ultimagold is considered better. It can be concluded that using ultimagold may provide more efficient and stable result and consequently more suitable as scintillator.

Keywords: scintillator, carbon-14, biodiesel, LSC

INTRODUCTION

Basic components of liquid scintillation counter consists of a photomultiplier tube (PMT), amplifier, discriminator, and counter pulses. In the PMT there are several consecutive dinode and given the potential difference that is one higher than the other, so that electrons will be pulled apart by electrodes in dinode, and it will produce more electrons are called secondary electrons. The secondary electrons will fall to the next dinode and the same process occurs so that the number of electrons will double (Tjahaja and Mutia, 2000).

Radioactive particles in the sample that is dissolved in a scintillator solution will collide with solvent molecules that cause the solvent molecules become excited. At the time of solvent molecules return to its original energy level occurs scattering energy, which in part is then forwarded to the scintillator molecules and re-causing molecules excited scintillator. At the time of its original energy level back to this, scintillator molecules emit photons. Photon then detected by the PMT, so that the resulting electrical pulses proportional to the energy of radioactive particles.

This paper will discuss the quality of scintillator solution on radioactivity measurements of carbon 14 in biodiesel sample. The purpose is to determine contribution of scintillator solution in the measurement of radioactivity of carbon-14 in biodiesel sample . Carbon-14 has six protons, eight neutrons and radioactive, so often called "radiocarbon". The half-life of ^{14}C, approximately 5,700 years (Sulzman, 2000).

Carbon-14 is a light-emitting radionuclides low energy beta (Bβ: 0.155 MeV), the data on the specific activity of the sample is very low, although the sample was still fresh.

METHODS

Emitted Beta particles resulting molecules in exited state and then transferred from molecule to molecule from primary scintillator. Primary scintillator molecules then deexited and emit energy in the form of photons with a specific wavelength characteristics. The resulting spectrum is then amplified by a secondary scintillator in order to achieve the appropriate wavelength measurable in PMT. The intensity of emitted light is proportional to the energy of beta particles. Interaction of energy transfer can be seen by the following sequence chart (Noor, 2003):

$$\beta^- + T \rightarrow T^*$$
$$T^* + S_1 \rightarrow T + S_1^*$$
$$S_1^* + S_2 \rightarrow S_1 + S_2^*$$
$$S_2^* \rightarrow S_2 + hv$$

Where: β- = beta particles, T = solvent molecule, S1 = primary scintillator, S2 = secondary scintillator and S2*= excited state of S2. Materials used as a scintillator in liquid scintillation technique is a mixture of several organic substances which are also called liquid scintillation (Cocktail). Prior to the census, radioactive samples should be dissolved in a liquid scintillator solution, then mixed with scintillation solvent and shaken until homogeneous. Furthermore, placed between two photon multiplier tube that is capable of responding when capturing the light of the scintillation (Elistina, 2007).

Materials and Equipment

Primary scintillators ; Aqualight, Aquasol, and Ultimagold, and Biodiesel samples from Pertamina Makassar. Instrument : Liquid Scintillation Counter Hidex 300 SL with a very sensitive TDCR detector carried out in Radiation Chemistry Laboratory.

Measurement of Activity of Carbon-14 in samples with LSC Hidex 300 SL (maming, 2014).

Carbon-14 activity in the sample is expressed in units of activity, which is the decay every minute (DPM) of carbon-14. Sample counting with liquid scintillation counter Hidex 300 SL generate data in units of CPM (counts per minute) and TDCR (Triple To Double Coincidence Ratio) or known as counting efficiency, E. (Maming 2014).

$$E = CPM / DPM \times 100\%$$

Statistical calculations using the radioactive sample counting with LSC is very natural decay calculations on radioactive element that emits pure beta particles every time (random decay).

Sample counting is done by filling in 8 mL of sample and 12 ml of scintillator into 20 mL plastic vial. Homogeneous mixture of sample and scintillator allowed to stand for 3 hours then counted by the LSC Hidex 300 SL at the time of counting 5-240 minutes.

RESULTS AND DISCUSSION

Sample counting of biodiesel can be seen in Table 1.

Table 1. Sample Counting Results Biosolar with Aquasol scintillator using LSC device Hidex 300 SL in a range 2-240 minutes

Sample Biodiesel				
No.	**Range (min)**	**CPM**	**DPM**	**TDCR**
1.	5	31,400	154,050	0,203
2.	15	27,600	87,220	0,316
3.	30	27,200	86,700	0,313
4.	60	28,710	100,770	0,284
5.	90	27,770	97,390	0,285
6.	120	28,840	94,240	0,295
7.	150	27,760	93,790	0,296
8.	180	28,170	94,460	0,298
9.	210	28,000	97,140	0,288
10.	240	28,570	98,250	0,290

Table 2. Results of Enumeration Sample Data Bio Diesel with scintillator Ultima Gold using LSC device Hidex 300 SL in a span of chopped 5-240 minutes.

Sample Biodiesel				
No.	**Shredded time (min)**	**CPM**	**DPM**	**TDCR**
1.	5	62,000	117,190	0,529
2.	15	58,460	108,630	0,538
3.	30	57,360	102,410	0,560
4.	60	59,080	115,570	0,509
5.	90	57,320	103,720	0,532
6.	120	58,400	107,760	0,542
7.	150	58,140	106,970	0,543
8.	180	58,450	105,700	0,553
9.	210	56,950	104,550	0,544
10.	240	57,500	107,850	0,533

Table 3. Results of Enumeration Sample Data Biosolar with Aqualight scintillator using LSC device Hidex 300 SL in a span of chopped 5-240 minutes.

Sampel Biodiesel				
No.	**Shredded time (min)**	**CPM**	**DPM**	**TDCR**
1.	5	71,200	139,270	0,511
2.	15	75,660	139,420	0,542
3.	30	73,330	128,860	0,569
4.	60	73,930	133,980	0,553
5.	90	71,130	127,200	0,559
6.	120	72,140	131,280	0,549
7.	150	72,480	130,030	0,557
8.	180	71,430	127,000	0,562
9.	210	76,820	146,600	0,523
10.	240	71,230	125,430	0,567

This research was carried out by using 3 scintillator solution is aquasol, ultimagold, and aqualight by means of LSC (Liquid Scintillation counter) Hidex 300 SL which plays an important role in detecting β particle emission of ^{14}C in the sample. Samples containing radionuclides in liquid scintillation counting method is dissolved or suspended in a solution of scintillator (Scintillator solution or cocktail) that fits inside the glass or plastic vial. Scintillator materials are materials which will emit photons when interacting with radiation particles (Yarianto, *et al.,* 2001). Scintillator is a transducer that converts light energy into light photon radiation. The entire LSC cocktail containing at least two scintillator. Primary scintillator causing major energy changes, but the wavelength of the light emitted does not correspond to the optimum detection wavelength of the detector PMT. Thus, the secondary scintillator (or wavelength shifter) is added to shift the wavelength of light emitted to fit the PMT detector.

In the enumeration process takes 8 mL of sample and 12 ml of scintillator were mixed into a 20 mL vial. The process of mixing the sample solution and the scintillator, avoiding contamination by free air containing CO_2-free. Radioactive particles in the sample is dissolved in a solution of scintillator will collide with solvent molecules that cause the solvent molecules become excited. At the time of solvent molecules return to its original energy level occurs scattering energy, which in part is then forwarded to the scintillator molecules and re-causing molecules excited scintillator. At the time of its original energy level back to this scintillator molecules emit photons. Photon then detected by the PMT, so that the resulting electrical pulses proportional to the energy of radioactive particles (Tjahaja and Mutia, 2000).

Based on a sample enumeration bio diesel with the respective third scintillator solution of the 5th minute to minute 120 decrease. But in the 150th minute of ^{14}C activity values ranging achieve stability.

^{14}C activity fluctuating values caused by the effects of chemical glow (chemiluminescence) when counting takes place and phase instability between the scintillator solution at the beginning of the enumeration process. Phase instability caused by the effects of extinction (quenhcing). Suppression effect is a shift in the fluorescence spectrum toward lower energy. The larger outage occurs, the fluorescence spectrum increasingly in the direction of lower energy (Yarianto, et al, 2001).

CPM impairment occurs because the number of nuclei that decay during a specific time interval decreases exponentially. Impairment CPM a sample is proportional to the decrease in the value of DPM but inversely proportional to the value TDCR sample. It can be seen from the value of the efficiency of enumeration (TDCR) for the use of biodiesel samples aquasol scintillator solution showed a low value is the average above 0.2. This is likely due to the scintillator solution aquasol usually used for samples containing water. While the efficiency of enumeration (TDCR) for the use of biodiesel samples ultimagold scintillator solution and aqualight shows average values above 0.5. Thus the solution of this scintillator efficiency enumeration value (TDCR) stable as a sign that the enumeration process for biodiesel samples running optimally.

But when compared with the data chopped samples using aqualight scintillator solution, count values in the sample with ultimagold scintillator solution shows a more stable value in the early minutes of enumeration. This is likely due to ultimagold scintillator containing organic compounds, resulting in a more stable interaction with biodiesel samples. ^{14}C activity values minute 90-240 start for the biodiesel sample using scintillator solution ultimagold also achieve stability. The cause is physical and chemical condition of the sample solution with a scintillator that is beginning to stabilize. The stability of the ^{14}C activity is essential for obtaining results chopped exponential graph.

5. Conclusion

From the measurement results it can be concluded that the best scintillator solution that can be used in measuring the activity of carbon-14 is based on the efficiency of enumeration (TDCR) biodiesel samples obtained 0.5 is ultimagold XR.

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